3. IRRIGATION AND RIVER TRAINI WORKS

Irrigation :-

Controlled application of water through man made system fo agricultural purpose.

Necessity of irrigation :-

1) inadequate rainfall
2) Uneven distribution of rainfall
3) Increasing yield of crop
4) Growing number of crops
5) Growing perrineal crops

Function / Advantages of irrigation :-

1) food production
2) flood control
3) Hydropower generation
4) water supply for domestic and industrial use
5) forestation.

Disadvantages of irrigation :-

- breeding place for mosquito
- Creats water logged area
- Crossing structure
- Damp climate

Status of irrigation ~~in Nepal~~ development in Ne

1) farmer use their own source, technique from past.
2) Government irrigation development started from 1979 BS.
3) 1st canal, chandra canal in saptari district in 1985 BS.
4) Juddha canal in sarlai & jagdispur reservion in Kapilbastu between 1932 - 1945.

) should not pass through residential area and public assessable flow area.
) should not pass through salty rock or broken strata.

Design capacity of canal

factor to be considered while designing capacity are
) Types of crop.
) peak crop requirement.
) peak water demand
) canal should be designed for non silting & non scouring velocity

Concept of sediment transport

velocity gradually increased then particle achieve threshold stage of motion.
) further increase, ripple are formed.
further increase, dunes are formed.
further increase, ripples disappear dune only left.
further increase both disappear, flat surface formed.
further increase, sand waves + surface waves formed.
) further increase antidunes are formed.

mechanics of sediment transport

) Incohesent soil :-
water exerts drag force on channel beg.
given by :-
drag force or tractive force or shear force ($\bar{c}$) = $\gamma_w \cdot R \cdot S$

Component of Canal irrigation system

Components are :-

1) Headwork :-
- store, divert and control the river waters.

2) Canal Network :-
a) main canal :→ seperates from headwork
b) Branch canal :- $Q > 5 m^3/s$
c) major distributaries :→ $5 - 0.25 m^3/s$
d) minor distributaries :→ $Q < 0.25 m^3/s$
e) water courses :- connects to fields

3) Structures in canal :-
a) Cross drainage structure :-
- constructed at crossing of canal and natural drainage.
b) Cross regulator :-
- provided on parent channel to raise water level.
c) Distributary head regulator :-
- head of each distributary and branch canal
d) outlets :-
- called modules
- discharge water to the area.

Alignment of Canal

factor to be consider during selecting canal are :-
1) minimum cross drainage structure.
2) most economical way of water distribution
3) High command area
4) most economical alignment, alignment on watershed
5) Length of main canal should be minimum between two points.

2) Incipient motion:
- condition in which sediment just begin to move is called incipient motion.

Design of canal

1. Design procedure by tractive force approach

1) determin R, $\tau = \tau_c = \gamma_w \cdot R \cdot S$

2) calculate V, $V = \frac{1}{N} R^{2/3} S^{1/2}$ ~~and~~

- $N = \left(\frac{1}{24}\right) d^{1/6}$

3) calculate A, $A = \frac{Q}{V}$

4) from R and A, find B and D.

Design of alluvial canals

a) Kennedy's method :-

- calculate critical velocity (V_o) = $0.55\, m . y^{0.64}$
  y = assumed depth
- calculate area (A) = $\frac{Q}{V_o}$
- determing A, R etc..
- Calculate actual velocity (v) using following formula.

a) Kutter's formula

$$V = \left(\frac{\frac{1}{n} + \left(23 + \frac{0.00155}{S}\right)}{1 + \left(23 + \frac{0.00155}{S}\right)\frac{n}{\sqrt{R}}} \right) \sqrt{RS}$$

b) manning's formula

$$V = \frac{1}{N} R^{2/3} S^{1/2}$$

c) chezy's formula

$$V = C\sqrt{RS}$$

5) if $V_o = V$ then assumed depth ok.
otherwise repeat process.

8) Lacey's Method :-

1) calculate velocity $(V) = \left(\frac{Qf^2}{140}\right)^{1/6}$

$$f = 1.76\sqrt{d_{mm}}$$

2) hydraulic depth $(R) = 2.5\left(\frac{V^2}{f}\right)$

3) calculate $(A) = \frac{Q}{V}$

4) calculated wetted perimeter $(P) = 4.75\sqrt{Q}$

5) calculate slope $(S) = \left(\frac{f^{5/3}}{3340\, Q^{1/6}}\right)$

3) Design of lined channel

a) Triangular/curved channel	b) Trapezoidal/flat bottom channel
1) $V = \frac{1}{n} R^{2/3} S^{1/2}$	1) $V = \frac{1}{n} R^{2/3} S^{1/2}$
2) $A = \frac{Q}{V}$	2) $A = \frac{Q}{V}$
3) $P = \frac{A}{R}$	3) $P = \frac{A}{R}$
4) $A = \frac{1}{2} d\cot\theta \times d \times 2 + \frac{1}{2} \times 2 \times \frac{2\pi d}{2\pi}\theta \times d = d^2(\theta + \cot\theta)$	4) $A = bd + d^2(\cot\theta + \theta)$
5) $P_{\text{perimeter}} = 2d(\theta + \cot\theta)$	5) $P = b + 2d(\theta + \cot\theta)$

4.4 Operation and maintainance of imgation system

A. Operation of imgation system :-

operation means storing, diverting, regulating, measuring, conveying and applying right amount of water at right time in right place to meet predetermined objectives.

the operation of imgation system is done by following agencies

i) operated by water users association (WUA)
   a) farmer managed imgation system
   b) imgation system handed over to WUA.
ii) operated by Government of Nepal (GON)
iii) operated by GON and WUA jointly.
iv) operated by WUA and LG jointly
v) operated by private sector.

- According to imgation policy 2072

S.N	Command area	operation, maintainance and construction
1)	<100 Hq	done by WUA
2)	100 - 500 Hq	WUA & GON
3)	>500 Hq	GON

B. Maintainance of imgation system

Types of maintainance are:-

) Routine maintainance

- Removal of debris & weed etc

2) periodic maintainance
- Reshaping of canal
- lining of canal
- maintance of structure

3) special maintainance :-
- maintance work related to damage done by natural calamities.

4) Deffered maintainance :-
- includes large modification to canal system and structure related to change occured in irrigation patter.

S.N	Reasons for maintainance	maintainance me
1)	silting of canal	a. Dredging b. excavation c. flushing by water d. silt scouring flut e. Iron race.
2)	Breaching due to weak of canal bank	strengthen the canal bank by :- a) internal silting syste b) external silting syste c) formation of berm by internal silting d. formation of berm by external silting.
3)	weed growth	remove the growth by a) High velocity b) Rush rotation c) plucking & burning weed
	erodation of canal bank	removing silt deposit

4.5 Management of farmer managed irrigation system

Aim of irrigation management

1) Economical use of water
2) safe delivery of water
3) protection & maintainance of irrigation works
4) protection of environment.
5) Manage application of water.

Types of irrigation management

1) farmer managed irrigation system
2) Agency managed irrigation system

farmer manged irrigation system (FMIS)

- Traditional System
- farmer is responsible for arranging water from source to field.
- operation, construction and maintainance is done by farmer.
- WUA is established to protect the farmers.
- according to fiscal year 2072/73, total irrigated area under FMIS = 2 lakh 3 thousand hachor.

- Examples of FMIS are
  i) panchakanya irrigation project
  ii) Chattish mauja Irrigation project
  iii) pragana irrigation project
  iv) Rajapur irrigation project.

Characteristics of system

- operation, construction & maintainance done by farmers.
- less liability of government to H.
- In emergency maintainance, government provide technical & financial support
- Manpower are trained at local level.
- Levy is fixed by WUA.

4.6. Preventive & Remedial measures of water logging

A) Causes of water logging :-

i) over irrigation
ii) Excessive rainfall
iii) frequent submergance
iv) seepage of water from adjoining high land
v) seepage of water from bed & side of channel or reservoir
vi)

B) Effects of water logging :-

1) crop yield reduced.
2) difficult in cultivation
3) salinity of soil
4) alkalinity of soil
5) defective air circulation
6) growth of wild aquatic plant.
7) reduction in maturity period.

C) preventive measures of water logging

1) Reducing intensity of irrigation
2) optimum use of water
3) adopt crop rotation
4) providing intercepting drains
5) improving natural drainage of soil:-
   - By clearing flow path
   - by desilting etc.
6) providing artificial drainage system
   - remover surplus water
7) lining of canal & water course
8) Introduction of lift irrigation:-
   - help to maintain water table

D) Remedial measures of water logging

1) controlling loss of water by seepage from canal.
2) providing adequate surface drainage.
3) providing efficient under drainage
4) charging irrigation tax on volumetric basis.

(4.7) flood control, its necessity and flood mitigation measures

A) Causes of flood

1) Heavy rainfall
2) melting of snow
3) obstruction to water flow

B) Necessity of flood estimation

1) design hydraulic structure
2) planning flood protection works
3) minimize loss of life and property

C) Method of flood control & design

flood can be controlled by

1) Structural measure

a) construction of levees & flood wall
b) construction of by-pass channel.
c) construction of storage reservior
d) improving the river capacity by improving its c/s
e) method of soil conservation.

2) Non-structural measures:

a) flood forecasting & warning
b) defining the flood zone

D) methods of flood estimation

1) slope-area method
2) probability method
3) Empirical formulae
4) rational formula
5) hydrograph method

E) flood mitigation reservious

1) storage reservior or detention basin
2) retarding reservoir or retarding basin
3) flood control reservoir.

Design of lined canal with economic analysis

A) Advantage of lining :-

1) control of seepage
2) control of flood
3) prevention of water logging
4) Increase in channel capacity
5) ~~Reduction~~ Increase in command area
6) Reduction in maintainance cost

B) Disadvantages of canal lining :-

1) High initial cost
2) damage lining is difficult to repair
3) In permanent lining difficult to shift outlets.
4) No provision of berm :- cause lack of safety for vehicles and pedestrians.

C) Requirement of good canal lining / factor to be considered

1) Durability :-

a canal must withstand :-

a) wear & tear
b) frost resistance
c) acid resistance
d) weather resistance
e) chemical attack
g) velocity effect

2) Repairability :-

- should be easily and economically repaired

3) Structural stability :-

- should withstand different pressure.

4) Economy :-
- economical from initial cost, repair and maintainance aspect.

5) Impermeability :-
- No seepage loss.

6) Hydraulic efficiency :-
- should have low coefficient of rugosity.
- hydraulically efficient

7) Resistance to erosion :-
- sediment transport should not cause erosion to bank.

Types of canal lining

1) Exposed and hard surface lining :-
- Cement concrete lining
- Cement mortar lining
- lime concrete lining
- Asphalt concrete lining
- shotcrete lining

2) Buried membrane lining :-
- sprayed in place asphalt membrane lining
- prefabricated asphaltic membrane lining
- polyethene film and synthetic rubber membrane lining
- Bentonite and clay membrane lining.

3) Earth lining :-
- thin compacted earth lining
- thick compacted earth lining
- loosely placed earth lining
- stabilized soil lining
- Bentonite soil lining.

Reclamation of water logged area

Reclamation means restoring productivity and feasibility of land.
The methods of reclamation are:-

1) Drainage and lowering water table :
- if water logging is caused by underground water then intercepting drain is used.
- if water logging is caused by surface water drainage system is provided.

2) leaching :-
- flooding the land by sufficient quantity of water.
- Remove excessive salt from land.

3) Use of chemicals :-
- Gypsum, calcium chloride and sulphuric acid is used as chemical
  i) Gypsum - remove sodium carbonate
  ii) Calcium chloride - remove less sodium carbonate than gypsum
  iii) Sulphuric acid - nutralize the alcalies in soil

4) Adopting rice cultivation :-
- Salinity of land is reduced.
- Carbon dioxide produced by plant reduce PH level of soil.

5) Crop rotation :-
- Salinity of land is reduced
- two crop rotation are used :-
  i) Rice in rotation
  ii) maize in rotation

6) Green manuring :-
- Lower pH and nitrogen in soil

7) Addition of agricultural waste products
- Salinity of soil is reduced.

8) Use of argenoma plant, processed coal and electrodialysis
- Reduce alcalinity of the soil.

Types of Drainage system

1) surface drainage system :-

i) shallow drainage system :- remove excess irrigation water remove storm water.

ii) Deep ~~surface~~ drainage system :- draining water logged area.

2) subsurface drainage system :-

* Layout of subsurface drainage system are :

1) Natural system :-

- preferred in rolling terrian.
- main are lateral are provided in this system

2) Grid iron system :-

- used in levelled land.
- consist lateral and submain

3) Herring bone system :-

- lateral join submain on each side

4) Double main system :-

- two seperate main with seperate lateral

5) ~~Double main system :-~~

6) Intercepting drainage system

- no lateral drains.
- submain is provided at toe of slope.

4.8 River Training Works

River training work implies various measures adopted on river to stabilize the river channel along certain alignment with certain cross section.

#OBJECTIVE / NEED :-

1) To safely pass the flood.
2) To prevent inudation of surrounding land
3) To prevent river changing its course.
4) To prevent erosion of bank.
5) To transport the sediment load.
6) To provide minimum water depth for navigation.
7) To deflect water from bank.

Classification of river training work

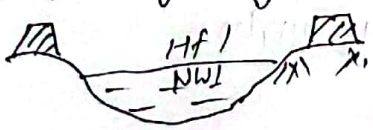
1) High water training work :-
- training for discharge.
- dispose excess flood.

2) low water training work :-
- Training for depth.
- spurs are constructed to increase the water depth.

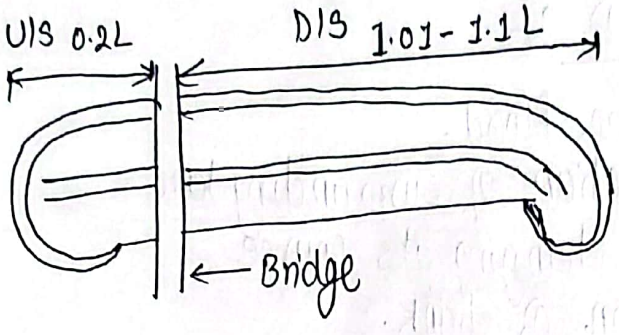
3) Mean water training work :-
- Training for sediments.

Methods of River training works

1) Embankment :-
- constructed on either both side bank
- protect the adjoining land from submerging.



2) Guide Bund :-
- confine large flow area to smaller section such as through under bridge, weir barrage etc.
- also called bund or bells bund.



3) Groynes :-
- constructed perpendicular to flow direction.
- constructed U/S and D/S.

Objectives :-
1) To channalize river in desired course.
2) to prevent the confined flow to one bank.
3) to provide slack zone for silting area

Types of Groynes
1) Classification based on method and materials of construction :-

a) Impermeable groynes :-
- do not permit appreciable water through it.
- can be designed as both attracting and repelling groynes.

b) Permeable Groynes :-
- permit restricted flow through it.
- block ~~sediment~~ and deposit sediment. So called sedimenting groynes.

2) Based on spur height :-
a) submerged groynes → below water
b) Unsubmerged groynes → above water

3) Based on function

a) Attracting groynes :-
- points D/S
- attract flow

b) Deflecting groynes:-
- points slightly U/S or constructed perpendicular to flow.
- deflect flow without repelling.

c) Repelling groynes :-
- points U/S
- repel flow away from bank.

4) Based on shape of spurs
- T-head, L-head, hockey type, circular head, rectangular head groynes or spur are used

Guideline for spur design or Consideration

1) permeability :-
- permeable spur → allow restricted water through it
- impermeable spur → do not allow appreciable water through it.

2) spur orientation :-
- can be attracting, deflecting or repeling spur.
- at head 1st spur is attraction to reduce impact of flow.

3) spur height :-
- submerged spur = (0.33 - 0.50) * water depth
- non submerged spur ⇒ height of bank.

4) spur shape :-
- oval or elliptical spur change hydraulic efficiency and reduce the impact of flood on spur.

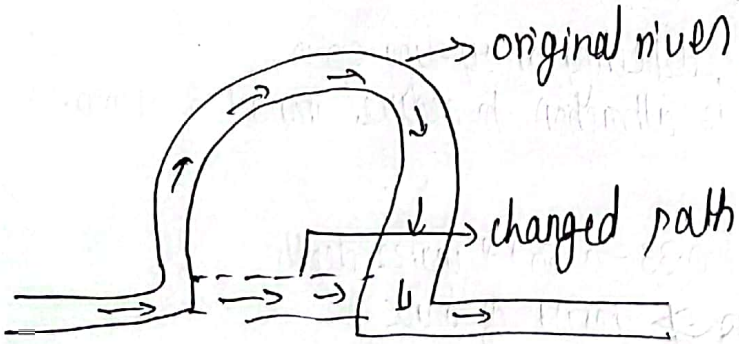
5) spur length
- spur length ≥ 2.5 * scour depth
  ≤ 0.2 * river width

6) spur spacing
- spacing = (2 - 2.5) * spur length in concave bank
  = (2.5 - 3) * spur length in convex bank

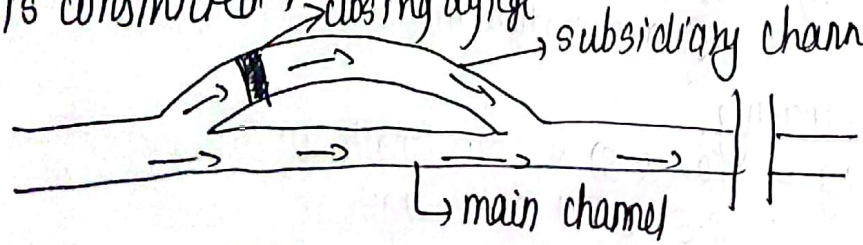
4) pitching of slope and subsiding apron :-
- Banks are protected by stone pitching, brush, wood etc.

5) pitched island :-
- artificial island
- constructed to deflect flow concentrating at one bank only.

6) ~~Cut off~~ cut-off :-
- River forms horse shoe hair pin bend some time
- During flood this bend is wholly submerged.
- Water starts to flow through straight reach.
- Due to flow v/s erosion occur deposition at d/s.
- to prevent this erosion soil is dug along straight length to prevent silting up.
- changing river course is eliminated.



7) closing dyke :-
- River flow through main channel and subsidiary channel.
- To prevent flow through subsidiary channel closing dyke is constructed.



4.9 Special consideration in Design, operation and management of hill irrigation system Canal

following consideration are made in design, operation and management of hill irrigation systems :-

A) Head work :-

1) structural design
2) U/S & D/S effect analysis
3) scour depth
4) water way
5) Bank height
6) flow velocity consideration
7) minimisation of effect
8) utility
9) overall efficiency

B) Canal & canal structures :-

1) head regulator
2) canal design
3) cross drainage structure
4) cross regulator
5) outlet
6) Branch canal
7) secondary canal
8) tertiary canal
9) Command area

C) Branch canal :-

1) Cross drainage work
2) road crossing
3) head regulator
4) outlet.

D) Secondary canal :-

1) Outlet
2) Distributor

E) Command area

F) Discharge

Design consideration for hydraulic structure in plain and hilly regions

S.N	Component	Hill	Teral
1.	Headwork	- stone masonry or gabion wall are provided from bank to some length - located at outside of bend.	- Barrage or weir throughout width of river is provided.
2.		canal	
a)	slope	variable bed slope to match soil condition	gentle slope due to weak soil.
b)	Types	contour canal with drop structure to over come rock cutting	ridge canal
c)	Area	small C/S area	large C/S area
d)	velocity	designed based on limiting velocity	design based on silting & non scouring velocity
3)	cross drainage structure	made of HDPE, RCC, stone masonry etc.	made of RCC
4)	Drop structure	maybe cascade, chute, pipe.	normall vertical

5@)	outlet	rigid module not preferred	all types may be used.

Other consideration for designing irrigation for Hilly area are :-

1) cost :-

2) water pressure and pipe size

3) worker safety

4) aim for irrigation deficit, non fully field capacity

5) Distribution of sprinkler unit.

6) water run off.

Note

- management system मा farmer management system भिन्न छ,
- यि सबै कुरा canal, irrigation system को भिन्न छ.